

REDOX PRACTICE

Name: _____



20 Assessment

* Solutions appear in Appendix E

Lesson by Lesson

20.1 The Meaning of Oxidation and Reduction

32. What chemical process must always accompany a reduction process?
33. What happens to an oxidizing agent during a redox reaction?
- *34. Balance each redox equation and identify whether the first substance in each equation was oxidized or reduced.
- $\text{Ba(s)} + \text{O}_2\text{(g)} \rightarrow \text{BaO(s)}$
 - $\text{CuO(s)} + \text{H}_2\text{(g)} \rightarrow \text{Cu(s)} + \text{H}_2\text{O(l)}$
 - $\text{C}_2\text{H}_4\text{(g)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)} + \text{H}_2\text{O(l)}$
 - $\text{CaO(s)} + \text{Al(s)} \rightarrow \text{Al}_2\text{O}_3\text{(s)} + \text{Ca(s)}$
35. Identify each process as either oxidation or reduction.
- $\text{Al} \rightarrow \text{Al}^{3+} + 3e^-$
 - $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2e^-$
 - $\text{S}^{2-} \rightarrow \text{S} + 2e^-$
 - $\text{Sr} \rightarrow \text{Sr}^{2+} + 2e^-$
- *36. Which of the following would most likely be oxidizing agents, and which would most likely be reducing agents? (*Hint*: Think in terms of tendencies to lose or gain electrons.)
- Cl_2
 - K
 - Ag^+
 - Zn^{2+}
- *37. Refer to the electronegativity values in Table 6.2 to determine which reactant is oxidized and which reactant is reduced in each reaction.
- $\text{H}_2\text{(g)} + \text{S(s)} \rightarrow \text{H}_2\text{S(g)}$
 - $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightarrow 2\text{NH}_3\text{(g)}$
 - $\text{S(s)} + \text{O}_2\text{(g)} \rightarrow \text{SO}_2\text{(g)}$
 - $2\text{H}_2\text{(g)} + \text{O}_2\text{(g)} \rightarrow 2\text{H}_2\text{O(l)}$
38. Identify the oxidizing agent and the reducing agent for each of the reactions in Problem 37.

20.2 Oxidation Numbers

39. In your own words, what is an oxidation number?

40. Which of these statements is false?

- The oxidation number of an uncombined element is zero.
- The sum of the oxidation numbers of the atoms in a polyatomic ion must equal the charge of the ion.
- Every element has a single oxidation number.
- The oxidation number of oxygen in a compound or a polyatomic ion is almost always -2 .

41. Determine the oxidation number of each metal atom.

- Ca^{2+}
- Al_2S_3
- Na_2CrO_4
- V_2O_5
- MnO_4^-

- *42. Assign oxidation numbers to the atoms in the following ions:

- OH^-
- PO_4^{3-}
- IO_3^-
- H_2PO_4^-
- HSO_4^-

20.3 Describing Redox Equations

43. Use the changes in oxidation numbers to identify which atoms are oxidized and which are reduced in each reaction.

- $\text{Al(s)} + \text{MnO}_2\text{(s)} \rightarrow \text{Al}_2\text{O}_3\text{(s)} + \text{Mn(s)}$
- $\text{K(s)} + \text{H}_2\text{O(l)} \rightarrow \text{KOH(aq)} + \text{H}_2\text{(g)}$
- $\text{HgO(s)} \rightarrow \text{Hg(l)} + \text{O}_2\text{(g)}$
- $\text{P}_4\text{(s)} + \text{O}_2\text{(g)} \rightarrow \text{P}_4\text{O}_{10}\text{(s)}$

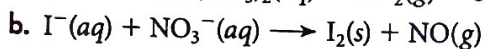
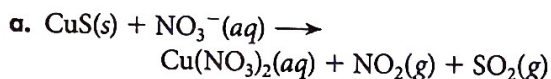
- *44. Balance each redox equation.

- $\text{Al(s)} + \text{Cl}_2\text{(g)} \rightarrow \text{AlCl}_3\text{(s)}$
- $\text{Al(s)} + \text{Fe}_2\text{O}_3\text{(s)} \rightarrow \text{Al}_2\text{O}_3\text{(s)} + \text{Fe(s)}$
- $\text{Cl}_2\text{(g)} + \text{KOH(aq)} \rightarrow \text{KClO}_3\text{(aq)} + \text{KCl(aq)} + \text{H}_2\text{O(l)}$
- $\text{HNO}_3\text{(aq)} + \text{H}_2\text{S(g)} \rightarrow \text{S(s)} + \text{NO(g)} + \text{H}_2\text{O(l)}$
- $\text{KIO}_4\text{(aq)} + \text{KI(aq)} + \text{HCl(aq)} \rightarrow \text{KCl(aq)} + \text{I}_2\text{(s)} + \text{H}_2\text{O(l)}$

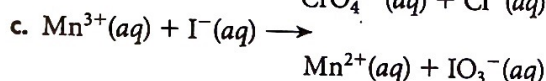
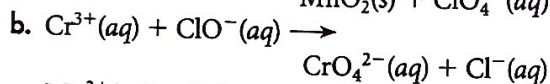
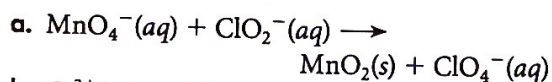
- *45. Identify which of these unbalanced equations represent redox reactions.

- $\text{Li(s)} + \text{H}_2\text{O(l)} \rightarrow \text{LiOH(aq)} + \text{H}_2\text{(g)}$
- $\text{K}_2\text{Cr}_2\text{O}_7\text{(aq)} + \text{HCl(aq)} \rightarrow \text{KCl(aq)} + \text{CrCl}_3\text{(aq)} + \text{H}_2\text{O(l)} + \text{Cl}_2\text{(g)}$
- $\text{Al(s)} + \text{HCl(aq)} \rightarrow \text{AlCl}_3\text{(aq)} + \text{H}_2\text{(g)}$
- $\text{Cl}_2\text{(g)} + \text{H}_2\text{O(l)} \rightarrow \text{HCl(aq)} + \text{HClO(aq)}$
- $\text{I}_2\text{O}_5\text{(s)} + \text{CO(g)} \rightarrow \text{I}_2\text{(s)} + \text{CO}_2\text{(g)}$
- $\text{H}_2\text{O(l)} + \text{SO}_3\text{(g)} \rightarrow \text{H}_2\text{SO}_4\text{(aq)}$

- *46. Use the half-reaction method to write a balanced ionic equation for each reaction. All occur in acidic solutions.

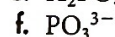
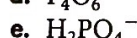
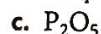
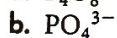
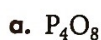


- *47. Use the half-reaction method to write a balanced ionic equation for each reaction. All occur in basic solutions.



Understand Concepts

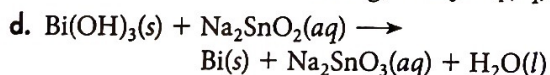
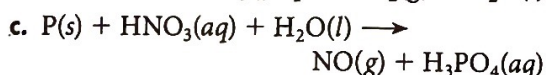
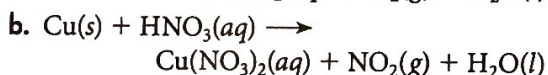
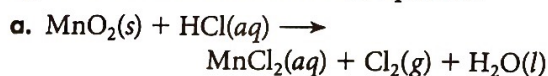
48. Balance the equations in Problem 43 by an appropriate method.
 49. Balance the equations in Problem 45 by an appropriate method.
 *50. Determine the oxidation number of phosphorus in each substance.



51. What is the oxidation number for chromium in each of these compounds?

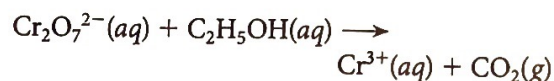


52. Identify the element oxidized, the element reduced, the oxidizing agent, and the reducing agent in each unbalanced redox equation.



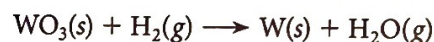
53. Balance each redox equation in Problem 52 by using the oxidation-number-change method.

- *54. An alcohol-content measuring device is used to test a person's breath for the alcohol ethanol, $\text{C}_2\text{H}_5\text{OH}$. In this test, ethanol reacts with an acidic solution of orange dichromate ion to form green chromium(III) ion.



The amount of color change is proportional to the amount of ethanol in the exhaled breath.

- a. Balance this equation by the half-reaction method.
 b. Is dichromate ion an oxidizing agent or a reducing agent?
 55. The metallic element tungsten, used as a filament in incandescent light bulbs, is obtained by heating tungsten(VI) oxide with hydrogen.



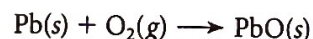
- a. Balance the equation.
 b. What is the reducing agent in this reaction?
 c. Which element undergoes an increase in oxidation number?
 56. Silver tarnishes when it reacts with hydrogen sulfide in the air.



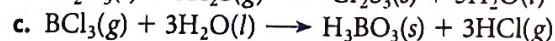
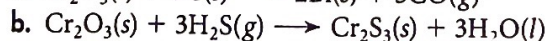
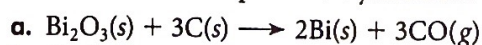
- a. Is silver oxidized or reduced in this reaction?
 b. Identify the oxidizing agent and the reducing agent.
 c. Balance the equation.



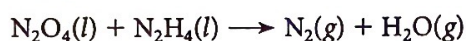
57. The following equation represents an oxidation-reduction reaction that uses oxygen. Show how this reaction can also be defined as an oxidation-reduction reaction in terms of electron transfer.



58. Does each of the following equations represent a redox reaction? Explain how you know.



- *59. Write chemical equations for the following redox reactions. Balance each equation using the oxidation-number-change method.
- Solid barium chlorate decomposes when heated, yielding solid barium chloride and gaseous oxygen.
 - Solid lead(II) sulfide reacts with gaseous oxygen to produce solid lead(II) oxide and gaseous sulfur dioxide.
60. The following unbalanced equation represents a reaction that can occur when dinitrogen tetroxide, N_2O_4 , is combined with hydrazine, N_2H_4 .



Balance the equation and describe in words the electron transfer that takes place.

61. Examine the following hypothetical redox equation.



- What is the oxidation number of element X on each side of the equation?
- What is the oxidation number of element Y on each side of the equation?
- What is oxidized in this equation?
- What is reduced in this equation?

Think Critically

62. **Explain** Why must the number of electrons lost equal the number of electrons gained in every redox reaction.
- *63. **Explain** The highest possible oxidation number that chlorine exhibits in any compound is +7, whereas its most negative oxidation number is -1. Write the electron configuration of chlorine, and explain why these are the limiting oxidation numbers for chlorine.
64. **Explain** Why is a sodium atom a reducing agent but a sodium ion is not?
65. **Explain** Many decomposition, single-replacement, combination, and combustion reactions are also redox reactions. Why is a double-replacement reaction never a redox reaction?
- *66. **Make Generalizations** Why must every redox reaction have a reducing agent and an oxidizing agent?

67. **Infer** Humankind began to make and use iron tools more than 3000 years ago, but few iron artifacts from ancient times have survived. Explain.

68. **Identify** Which substance in each pair is more likely to be an oxidizing agent?

- S^{2-} or SO_4^{2-}
- H_2O or H_2O_2
- NO_2^- or NO_3^-
- $\text{Cr}_2\text{O}_7^{2-}$ or Cr^{3+}
- H_2 or H_2O

69. **Identify** Which is more likely to be a strong reducing agent, a group 1A metal or a group 7A nonmetal? Explain.

- *70. **Predict** Predict the product(s) and write the balanced equation for each of these redox reactions. Identify the oxidizing agent in each reaction.

- rubidium + iodine \longrightarrow
- barium + water \longrightarrow
- aluminum + iron(II) sulfate \longrightarrow
- butene (C_4H_8) + oxygen \longrightarrow
- zinc + hydrobromic acid \longrightarrow
- magnesium + bromine \longrightarrow

71. **Explain** The electronegativity of rhenium, Re, is 1.9, and the electronegativity of selenium is 2.4. If rhenium were to react with selenium to form a compound, which element would be oxidized and which element would be reduced? Explain.

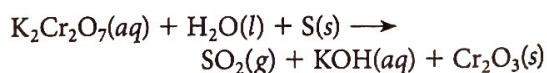
72. **Explain** Which of the following ions is most likely to be an oxidizing agent? Explain your choice.



Enrichment

- *73. **Calculate** How many grams of copper are needed to reduce completely the silver ions in 85.0 mL of 0.150M $\text{AgNO}_3(aq)$ solution?

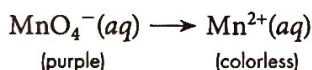
74. **Calculate** How many milliliters of 0.280M $\text{K}_2\text{Cr}_2\text{O}_7(aq)$ solution are needed to oxidize 1.40 g of sulfur? First, balance the equation.



75. **Calculate** Carbon monoxide can be removed from the air by passing it over solid diiodine pentoxide.



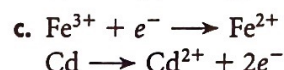
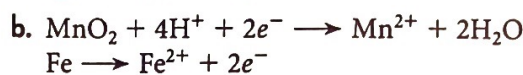
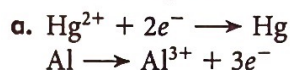
- Balance the equation.
 - Identify the element being oxidized and the element being reduced.
 - How many grams of carbon monoxide can be removed from the air by 0.55 g of diiodine pentoxide (I_2O_5)?
76. **Calculate** What is the oxidation number of nitrogen in each of these species?
- HNO_3
 - NH_3
 - N_2O_3
 - NO_2^-
 - N_2O
 - NH_4Cl
 - NO
 - NO_2
77. **Calculate** The elements fluorine and oxygen can react to form fluorine monoxide, F_2O . Write the balanced chemical equation for this reaction. Check electronegativity values, and then identify the elements oxidized and reduced.
78. **Explain** The oxidation number of nitrogen can range from a minimum of -3 to a maximum of $+5$. Use this information to explain why the nitride ion, N^{3-} , can act only as a reducing agent, and why the nitrate ion, NO_3^- , can act only as an oxidizing agent.
79. **Calculate** Oxidation-reduction reactions form the basis for chemical analysis by redox titration. Potassium permanganate, a good oxidizing agent, is sometimes used as a titrant because it undergoes a color change as it is reduced.



Write a balanced redox equation for the oxidation of stannous ion to stannic ion in acidic solution using permanganate as the oxidizing agent.

- *80. **Describe** There are a number of anions that are commonly used as oxidizing or reducing agents in the laboratory. Balance each of these half reactions. Identify each of the anions as an oxidizing or reducing agent.
- $\text{Cr}_2\text{O}_7^{2-}(aq) \rightarrow \text{Cr}^{3+}(aq)$ [acidic solution]
 - $\text{S}_2\text{O}_3^{2-}(aq) \rightarrow \text{SO}_4^{2-}(aq)$ [acidic solution]
 - $\text{CrO}_4^{2-}(aq) \rightarrow \text{Cr}(\text{OH})_3(aq)$ [basic solution]
 - $\text{MnO}_4^-(aq) \rightarrow \text{Mn}^{2+}(aq)$ [acidic solution]
 - $\text{C}_2\text{O}_4^{2-}(aq) \rightarrow \text{CO}_2(g)$ [acidic solution]
 - $\text{MnO}_4^-(aq) \rightarrow \text{MnO}_2(s)$ [basic solution]

81. **Calculate** Combine each of the following pairs of half-reactions into a complete, balanced, ionic redox equation.




Write About Science

82. **Explain** Silver recovered from shipwrecks may have layers of black tarnish. Research and write a report on how the thick layers of tarnish are removed from the silver artifacts.
83. **Connect to the BIG IDEA** Write a paragraph about five different real-world examples of oxidation-reduction reactions.

CHEMYSTERY

Tarnished Treasure



Gold and silver coins recovered from the same shipwrecked Spanish galleons were exposed to the same elements of the sea. However, the silver coins corrode faster than gold coins because silver is more easily oxidized than gold. Oxidation reactions cause silver coins to corrode, eventually causing their surface to become black and crumbly. Since gold is not as easily oxidized, the gold coins retain their gold color and do not show as many signs of oxidation.

84. **Infer** Suppose there were two types of coins, one made of magnesium and one made of iron. Which coin would you expect to tarnish faster if they were both exposed to the same conditions?
85. **Connect to the BIG IDEA** Why would it be helpful for shipbuilders to have a knowledge of redox reactions?

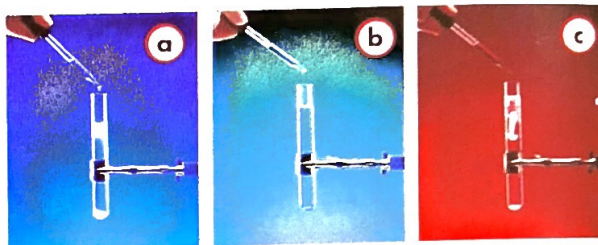
Cumulative Review

- *86. The complete combustion of hydrocarbons involves the oxidation of both carbon and hydrogen atoms by oxygen. The following table lists the moles of O_2 used, and the moles of CO_2 and moles of H_2O produced, when a series of hydrocarbons called alkanes are burned.

Alkane burned	O_2 used (mol)	CO_2 produced (mol)	H_2O produced (mol)
CH_4	2	1	2
C_2H_6	3.5	2	3
C_3H_8	5	3	4
C_4H_{10}	a. _____	d. _____	g. _____
C_5H_{12}	b. _____	e. _____	h. _____
C_6H_{14}	c. _____	f. _____	i. _____

- a. Complete the table.
 b. Based on the data, write a balanced generalized equation for the complete oxidation of any alkane. Use the following form, and write the coefficients in terms of x and y :
- $$C_xH_y + \text{_____ } O_2 \longrightarrow \text{_____ } CO_2 + \text{_____ } H_2O$$
87. Name a change of state that does not involve a liquid.
- *88. A gas cylinder has a volume of 6.8 L and is filled with 13.8 g of N_2 . Calculate the pressure of N_2 at $25^\circ C$.
89. A particular paint must be stirred before using. Is the stirred paint a solution or a suspension? Explain.
90. Which of these are nonelectrolytes?
 a. $S(s)$ c. $SiO_2(s)$
 b. $NH_4Cl(aq)$ d. $F_2(g)$
- *91. How would you make 440 mL of 1.5M HCl solution from a stock solution of 6.0M HCl?
92. One mole of LiF and $Ca(NO_3)_2$ are each dissolved in 1.0 L of water. Which solution has the higher boiling point? Explain.

93. What is the molarity of the solution prepared by dissolving 46.4 g H_3PO_4 in enough water to make 1.25 L of solution?
- *94. The K_{sp} of lead(II) bromide ($PbBr_2$) at $25^\circ C$ is 2.1×10^{-6} . What is the solubility of $PbBr_2$ (in mol/L) at this temperature?
95. A reaction goes essentially to completion. Do you expect the value of K to be large or small?
96. Bottles containing 0.1M solutions of Na_2SO_4 , $BaCl_2$, and $NaCl$ have had their labels accidentally switched. To discover which bottle contains the $NaCl$, you place a clear saturated solution of $BaSO_4$ ($K_{sp} = 1.1 \times 10^{-10}$) into three test tubes. To each test tube you add a few drops of each mislabeled solution. The results are shown below. To which tube was $NaCl$ added? Explain.



97. What is the hydrogen-ion concentration of solutions with the following pH?
 a. 2.00 b. 11.00 c. 8.80
98. How many milliliters of a 4.00M KOH solution are needed to neutralize 45.0 mL of 2.50M H_2SO_4 solution?
99. Identify the conjugate acid-base pairs in each equation.
 a. $NH_4^+(aq) + H_2O(l) \longrightarrow NH_3(aq) + H_3O^+(aq)$
 b. $H_2SO_3(aq) + NH_2^-(aq) \longrightarrow HSO_3^-(aq) + NH_3(aq)$
 c. $HNO_3(aq) + I^-(aq) \longrightarrow HI(aq) + NO_3^-(aq)$
- *100. Calculate the pH of solutions with the following hydrogen-ion or hydroxide-ion concentrations. Classify each as acidic, basic, or neutral.
 a. $[H^+] = 0.000\ 010M$
 b. $[OH^-] = 1.0 \times 10^{-4}M$
 c. $[OH^-] = 1.0 \times 10^{-1}M$
 d. $[H^+] = 3.0 \times 10^{-7}M$

If You Have Trouble With . . .

Question	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
See Chapter	12	13	14	15	15	16	16	16	18	18	19	19	19	19	19

Standardized Test Prep

Select the choice that best answers each question or completes each statement.

- Which of these processes is not an oxidation?
 - a decrease in oxidation number
 - a complete loss of electrons
 - a gain of oxygen
 - a loss of hydrogen by a covalent molecule
- In which of these pairs of nitrogen-containing ions and compounds is the oxidation number of nitrogen in the ion higher than in the nitrogen compound?
 - N_2H_4 and NH_4^+
 - NO_3^- and N_2O_4
 - N_2O and NO_2^-
 - I only
 - I and II only
 - I and III only
 - II and III only
 - I, II, and III
- Identify the elements oxidized and reduced in this reaction.

$$2\text{ClO}^- + \text{H}_2 + 2e^- \rightarrow 2\text{Cl}^- + 2\text{OH}^-$$
 - Cl is oxidized; H is reduced
 - H is oxidized; Cl is reduced
 - Cl is oxidized; O is reduced
 - O is oxidized; Cl is reduced
- Which of these half-reactions represents a reduction?
 - $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$
 - $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+}$
 - $\text{MnO}_4^- \rightarrow \text{Mn}^{2+}$
 - I and II only
 - II and III only
 - I and III only
 - I, II, and III
- Which of these general types of reactions is not a redox reaction?
 - single replacement
 - double replacement
 - combustion
 - combination
- What is the reducing agent in this reaction?

$$\text{MnO}_4^- + \text{SO}_2 \rightarrow \text{Mn}^{2+} + \text{SO}_4^{2-}$$
 - SO_2
 - SO_4^{2-}
 - Mn^{2+}
 - MnO_4^-

Tips for Success

Interpreting Data Tables To interpret the content in a table, start by reading the title (if there is one). Then, read the headings. Try to figure out the relationship between the different columns and rows of information. Ask yourself: *What information is related in the table? How are the relationships represented?*

Use the table to answer Questions 7–9.

Metal		Metal ion
3	K	K^+
	Ca	Ca^{2+}
	Na	Na^+
4	Mg	Mg^{2+}
	Fe	Fe^{2+}
	Sn	Sn^{2+}
	Pb	Pb^{2+}
5	Cu	Cu^{2+}
	Ag	Ag^+

- Which arrow indicates increasing ease of oxidation? Of reduction?
- Which numbered group of metals are the strongest reducing agents? Which numbered group of metals are the most difficult to oxidize?
- Which is a stronger oxidizing agent, Na or Fe?

Use this diagram to answer Questions 10 and 11. It shows the formation of an ion from an atom.



- Does the diagram represent oxidation or reduction? Does the oxidation number increase or decrease when the ion forms?
- Draw a diagram showing the formation of a sulfide ion from a sulfur atom. Make the relative sizes of the atom and ion realistic. Does your drawing represent an oxidation or a reduction?

If You Have Trouble With . . .

Question	1	2	3	4	5	6	7	8	9	10	11
See Lesson	20.1	20.2	20.2	20.2	20.3	20.3	20.2	20.2	20.2	20.2	20.1